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1963 KVICHAK RIVER RED SALMON SMOLT STUDIES

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Introduction

The 1963 Kvichak River smolt studies were conducted by the Alaska Department of Fish and Game. The Division of Commercial Fisheries provided material and personnel for this project. Mr. Richard Marriott (presently with the Division of Sport Fish, ADF&G) served as project leader and author of this report. Others assisting in the analysis of the data and the editing and assemblage of this report were Mr. Steven Pennoyer, Mr. Melvin C. Seibel, and Mr. Frank Ossiander.

Relative abundance indices of the Kvichak River red salmon smolt migration started by the Fisheries Research Institute in 1955 and maintained by the Alaska Department of Fish and Game since 1961, have been used as one method of predicting the size of returning salmon runs. These predictions are needed for the planning of industry operations and for subsequent management regulations. However, the major long-term value of the study appears to be in the evaluation of the survival of the progeny of various spawning escapement levels for establishing the most efficient management of the resource. The 1963 smolt migration of Age II smolts (fish that have spent two winters in the lake after hatching) was of particular concern, for the 1960 parent escapement of 14.6 million red salmon was the largest recorded in over 10 years of observation. Furthermore, the 1962 smolt migration age Age I smolt (fish that have spent one winter in the lake after hatching) from this same parent escapement was only about 30 percent of the expected magnitude. This latter result aroused speculation that either there had been a large holdover of Age II smolts or a higher freshwater mortality affecting the progeny of the 1960 escapement. Increased mortality could be due to a number of factors, but because of the exceptionally large size of the 1960 escapement, possible over-utilization of the rearing areas in Lake Iliamna was the most discussed hypothesis.

Objectives

The objectives of the smolt work are: (1) to determine the relative abundance of the 1963 smolt migration by a method comparable with previous years; (2) to determine the age, size, and condition of the 1963 smolts; (3) to evaluate the implications of the smolt data collected since 1955; and (4) to include an outline of procedures that have evolved in the collection and analysis of data from the Kvichak River smolt program.

Attention should be given to publications produced in connection with this study in previous years as noted in the literature citations. The author has freely used data from these publications without reference.

General Methods

Since total enumeration of smolts has not yet proved feasible in the Kvichak River, an indexing approach has been maintained throughout the years of obser-

vation. This indexing consists of fishing a standard fyke net in the same location and depth each year to obtain a comparative catch. The net of one-inch cotton mesh is set in 4 feet of water and fishes a nine-foot wide section of the river. As no effort is made to estimate the total outmigration, the seasonal index catches cannot be used for determination of absolute freshwater survival, but are considered to furnish a reliable yearly comparison.

In the early years 1955 through 1961, only the catches during the 3-hour index period (2200 to 0100) were used for calculations since this is the time period when the major portion of the migration usually occurs. However, from extensive 24-hour catch data collected in more recent years, it became apparent that, especially during years of large outmigration, the catch distribution over a 24-hour period fluctuates greatly, producing a larger relative percentage of migration during the non-index hours. Due to these large flucutations in migrations of smolt during the non-index hours, any relative production index based on fishing only a 3-hour period cannot adequately reflect changes in smolt abundance from year to year. For this reason 24-hour fishing was initiated on the Kvichak River in 1962 and will be continued in future years. However, since only four years of actual 24-hour sampling (1957, 1958, 1962, and 1963) are presently available, much of our analysis and thinking may have to be based on 3-hour indices, for which we have a complete nine year series, until more accurate 24-hour data is collected.

For the sake of comparison, in the 1962 Kvichak smolt report visual observations and limited sampling results were used to expand the smolt indices for the years 1955, 1956, 1959, 1960, and 1961 to a 24-hour basis. This derived 24-hour series is used in this report for comparison with the 1963 outmigration.

A catch unit called an index point was defined to compare year index catches. Each year's catch was assigned an index value using 1958 as the base year. The 1958 catch of 3,334,000 smolts, as expanded to the 24-hour base, was assigned a value of 100 index points. Consequently, a year with a seasonal catch of 1,667,000 smolt, using the 24-hour index base, would represent a value of 50 index points. The original 3-hour index also used 1958 as the base year. In 1958 an estimated 1,912,767 smolt were caught during the index hours 2200-0100, and this number of smolt was equated to 100 index points. Therefore, one 3-hour index point is equal to 19,128 smolt. The 1963 smolt outmigration will be given in terms of both 24-hour and 3-hour index points in this report.

To safely handle the large numbers of smolts caught in the fyke net, photo-electric counting methods have been developed in recent years to replace the use of cod-ends. The photo-electric counter consists of a metal tunnel attached to the throat of the fyke net. Two lights and two corresponding photo-cells are mounted in the tunnel so that passing smolts will break the light beams and be recorded on automatic counters in the fyke net skiff. Because this pair of photo-cells only counts approximately one-seventh of the passing smolts, the counting apparatus must be periodically calibrated by attaching a cod-end behind the tunnel and obtaining the number of smolts caught per set number of counts on the counters. These periods of calibration also enable smolt samples to be obtained for determining age and condition.

Index of Abundance of the 1963 Migration

The 1963 smolt index was obtained by fishing the standard smolt fyke net at the index site on a 24-hour basis, using the same procedures as in previous years. The use of photo-electric counters was maintained whenever possible to facilitate handling the large numbers of smolts in the 1963 outmigration.

Fyke netting operations began on May 15 when the water temperature was 36.5° Fahrenheit. Despite some ice flow, intermittent fishing was maintained through the evening of May 19. During this time an estimated total of only 203 smolts were caught. From May 20 through May 23 the outflow of ice from Lake Iliamna was too heavy for boats to venture on the river for smolt observations of any type. Significantly, during this time, water temperatures remained well below 36° Fahrenheit. In all past years of observation, no significant smolt migration has ever occurred when water temperatures were below this level. On May 24, the water temperature rose to 36° F. and the ice cleared enough for sporadic fishing during the afternoon and first evening index hour (2200-2300). Good catches were made during the periods that were fished and observations made during the remainder of the night indicated that a substantial migration had begun. Again on May 25 extremely heavy ice flow curtailed all smolt observations, although the water temperature remained above 36° F. By the evening of May 26, conditions had improved enough for a 2-hour series of catches, during the index hours. Despite moderately heavy catches, it was possible to maintain the net without the use of photo-counters in order to enable quick collapse and resetting among ice flows. From May 27 through June 1, ice continued to plague the operation, but did not curtail fishing for any extended period nor prevent the use of photo-counting equipment. Fyke netting continued until June 16 when the program was terminated.

In 1962 the sensitivity of the photo-electric counters was adversely influenced by faulty rheostats. Consequently, in 1963 the photo-electric counter units were operated at full sensitivity without rheostat adjustment.

Basic photo-electric counter calibration data is given in Table 1. This table gives the individual photo-electric counts per minute, the fyke net catch per minute and the corresponding ratios of smolt per photo-electric count. In addition, a plot of fyke net catch per minute against photo-electric counts per minute is shown in Figure 1. The linear correlation coefficient $r = 0.958$ represents a highly (99% level) significant linear correlation between these two variables, and the resulting linear regression line is also shown in Figure 1. The data in Table 1 includes a wide range of counting rates and passage rates, with up to 2,000 counts per minute and catches up to 13,500 smolt per minute. The heaviest passage rates previously recorded using photo-electric counters were 2,200 smolt per minute in 1962 and 2,900 smolt per minute in 1959; these rates being approximately one-fifth the 1963 maximum.

The slight decrease in counter efficiency, with higher passage rates, as evidenced by the fact that the line in Figure 1 does not pass through the origin, corresponds with the evidence of reduced efficiency during high migration levels which occurred in 1959 and 1962. It was felt however that this relatively small change in counter efficiency would be compensated for by using the daily ratios of smolt per photo-electric count. It should be noted that there was very little difference between these daily ratios.

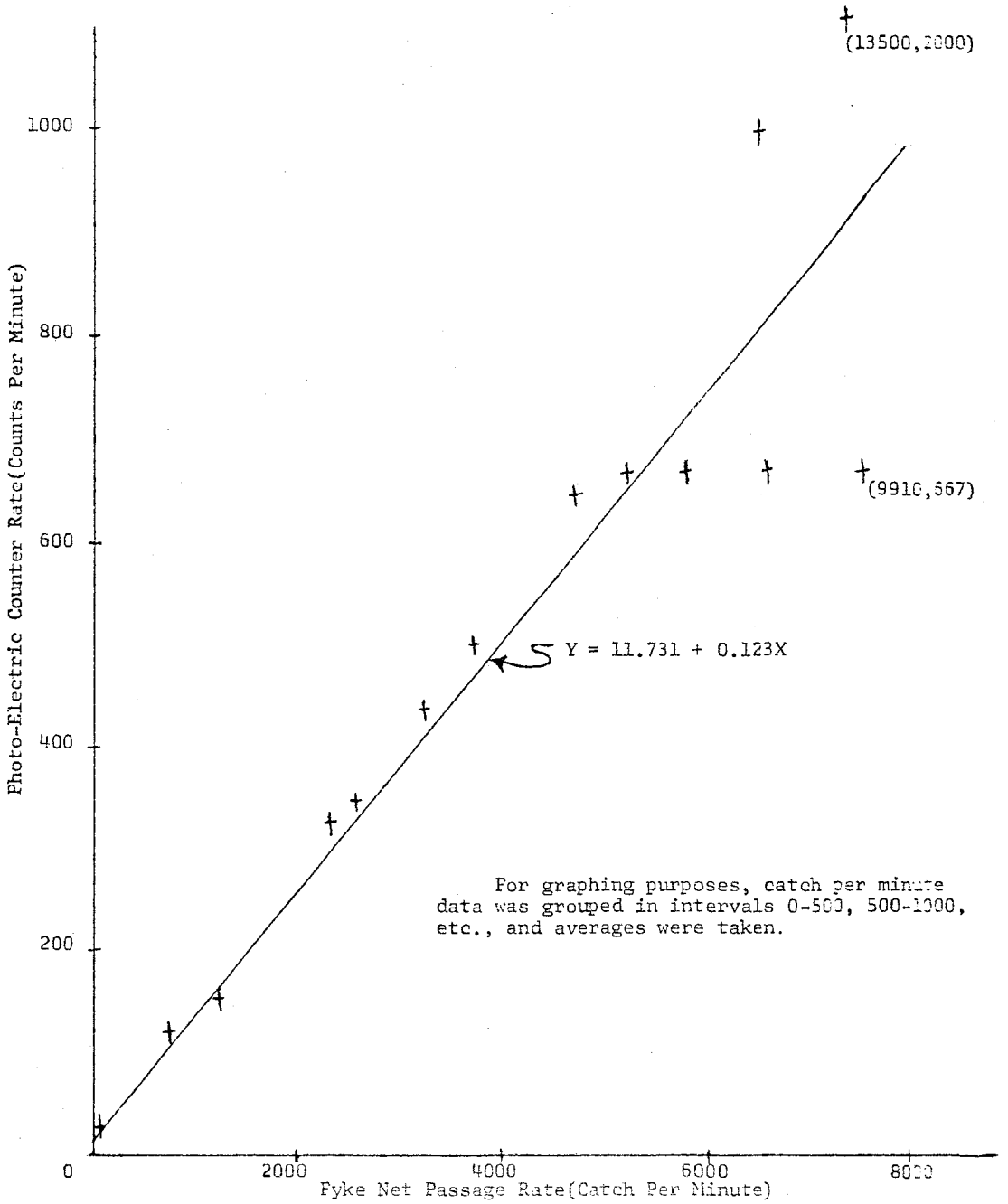

Figure 1. Comparison of photo-electric counter rates and fyke net passage rates - Kvichak River, 1963.

Observation of the cod-end catch per photo-electric count ratio in Table 1 gave no evidence of changed counter efficiency during the season. However, enough daily differences did occur to warrant the use of daily catch per count ratios instead of a seasonal average value. In days where no conversion factors were obtained, the seasonal average of 7.21 smolt per photo-electric count has been used.

Table 2 shows the distribution of fyke net catches by day for the various time periods into which the data was arbitrarily divided. These are 1200-2200, the index hours (2200-2300, 2300-2400, 0000-0100) and 0100-1200 hours. The data in this table has been subjected to only preliminary analysis. Photo counts have been converted into numbers of smolt and total catch per time period per day has been derived by expanding available counts within the time period. Dashes indicate that no count was made and zeros indicate that the period was fished but there was no catch. Other items of interest are footnoted. Figures in parenthesis under the index hour columns represent hours not actually fished. They were calculated by expanding catches for index hours that were fished on the same date. The 24-hour total column lists catches only for complete days.

Table 3 shows the catch ratios between time periods. The total catches for other periods are compared with the 3-hour index total for corresponding days and a ratio between the two is given. These seasonal ratios are used to estimate missing periods in Table 4. The ratios are numbered and estimated catches in Table 4 are correspondingly numbered to identify the ratio used to derive them.

Table 4 shows the final estimated catches by time period and day and the 24-hour index points derived from them (one index point = 33,340 smolt). Figures in parenthesis have been either derived from the seasonal period catch ratios (identified by numbers) or subjective interpolation (footnoted).

Subjective treatment of the data has been kept as conservative as possible. However, due to ice conditions there were many hours and even days when the net could not be fished. Interpolation for missing periods or days (by either subjective treatment or period catch ratios) accounted for approximately 17.8 index points. Another source of possible error was the expansion of small samples within a time period to represent the whole time period. Expanded catches for time periods in which less than 30% of the hours within the period were adequately sampled on a given day accounted for approximately another 9.3 index points. However, the 9.3 index points is not necessarily an over-estimate, since several zero counts were also expanded to cover whole periods. In total then, approximately 27.1 index points were arrived at by expansion of small samples or interpolation of one form or another. This amounts to only 21% of the total index of 126.86. This total catch, being 1.3 times the magnitude of the record 1958 Kvichak River smolt migration, is considered to be an index measurement of the largest smolt migration ever observed.

The daily index catches from Table 4 have been plotted in Figure 2.

Table 1. Red salmon smolt photo-electric calibration data - Kvichak River, 1963.

Daily Period[1/]	Hour	Minutes Elapsed	Photo-Counter Tally	Fyke Net Catch	Smolts per Tally	Daily Smolts/count	Photo Counts per Minute	Fyke Net Catch Per Minute
5/27-28	1600	28.2	200	1180	5.90		7	42
	2200	0.3	200	1539	7.70		667	5130
	2200	0.4	200	1475	7.38		500	3688
	2200	0.4	200	1375	6.88		500	3438
	2200	0.4	200	1224	6.12		500	3060
	2200	0.3	200	1357	6.78		667	4523
	2200	0.4	200	1560	7.80		500	3900
	2200	0.5	200	1098	5.49		400	2196
	0000	0.3	200	1972	9.86		667	6567
	0000	0.3	200	1540	7.70		667	5128
	0000	0.6	200	1800	9.00		334	3006
	0000	0.3	200	2976	14.88		667	9910
	0000	0.3	200	1566	7.83		667	5215
	0000	0.1	200	1350	6.75		2000	13,500
	0000	0.3	200	1728	8.64		667	5754
	0000	0.4	200	1416	7.08		500	3540
	0000	0.3	180	1392	7.73		599	4635
	0000	0.3	200	1972	9.86		667	6567
	0000	0.3	200	1475	7.38		667	4912
Daily Totals			3780	29,995		7.94		
5/28-29	1300	8.1	200	1848	9.24		25	227
	0000	0.5	200	1292	6.46		400	2584
	0000	0.2	200	1292	6.46		1000	6460
Daily Totals			600	4432		7.39		
5/29-30	1800	33.7	75	402	5.36		2	12
	2200	4.0	200	1062	5.31		50	266
	2200	1.9	200	1020	5.10		105	541
	2200	3.8	200	960	4.80		52	250
	0000	18.7	200	1037	5.18		11	55
	0000	32.8	64	366	5.72		2	11
Daily Totals			939	4847		5.16		
6/2-3	2200	12.4	200	1273	6.36		16	103
	2300	6.0	200	1292	6.46		33	216
	0000	3.3	200	1104	5.52		61	335
	0000	18.2	200	726	3.63		11	40
Daily Totals			800	4395		5.49		
6/5-6	2200	50.0	228	1491	6.54		5	30
	0000	28.0	135	1349	9.99		5	49
	0000	24.0	147	1207	8.21		6	51
Daily Totals			510	4047		7.94		
6/6-7	0000	22.8	200	1235	6.18		9	54
Daily Totals			200	1235		6.18		

(Continued)

Table 1. Red salmon smolt photo-electric calibration data - Kvichak River, 1963 (continued).

Daily Period[1]	Hour	Minutes Elapsed	Photo-Counter Tally	Fyke Net Catch	Smolts per Tally	Daily Smolts/count	Photo Counts per Minute	Fyke Net Catch Per Minute
6/7-8	1500	14.0	210	1872	8.91		15	133
	2100	0.8	200	1872	9.36		250	2340
	2100	10.0	200	1314	6.57		20	131
	2200	3.5	200	1346	6.73		58	390
	2300	1.3	200	1606	8.03		154	1237
	0000	0.7	200	1750	8.75		286	2502
	0000	0.5	200	1600	8.00		400	3200
	0000	1.6	200	1452	7.26		124	900
	0000	4.5	200	1340	6.70		44	295
Daily Totals			1810	14,152		7.82		
6/11-12	1500	9.6	200	980	4.90		21	102
	2200	30.0	46	259	5.63		1	8
Daily Totals			246	1239		5.04		
6/12-13	0000	30.0	43	175	4.07		1	6
Daily Totals			43	175		4.07		
6/14-15	2200	7.0	200	1300	6.50		29	186
	2300	30.0	63	351	5.57		2	11
	0000	30.0	91	780	8.57		3	25
Daily Totals			354	2431		6.87		
SEASONAL TOTALS			9,282	66,948		7.21		

[1] Daily periods are from 12 noon of one day to 12 noon of the following day.

Table 2. Distribution of red salmon index catches by day and time period - Kvichak River, 1963.

Daily Period	Hourly Periods: Index Hours 2200-2300	2300-2400	0000-0100	3-hour Index	1200-2200	0100-1200	24-hour Total
May 16-17	0	4	5	9	37	-	
17-18	No fishing due to ice						
18-19	(14)	6[1]	22[1]	42	0	-	
19-20	1	(1)	(1)	3	0	-	
20-24	No fishing due to ice						
24-25	36,599[1]	(36,599)	(36,599)	109,797	122,738[1]	-	
25-26	No fishing due to ice						
26-27	3,177[1]	32,731[1]	2,599[1]	38,507	0	-	
27-28	219,467[1]	257,598[1]	311,860[1]	788,925	53,009[1]	765,680[1]	1,607,614
28-29	6,515[1]	78,715[1]	60,823[1]	146,053	152,748[1]	504,739[1]	803,540
29-30	14,469[1]	19,874[1]	1,900[1]	36,243	55,025[1]	7,809[1]	99,077
30-31	-	-	-	-	43,460	0	
31 - June 1	-	-	0	0	120	16	136
1-2	303	310	151	764	31	1,362	2,157
2-3	9,734	16,525	4,650	30,909	10,961[1]	-	
3-4	87	7	22	116	25,954	-	
4-5	937	2,862	0	3,799	892	-	
5-6	1,977	9,274	2,819	14,070	1,135	145,766	160,971
6-7	5,945	6,322	4,672	16,939	12,417	-	
7-8	27,620	50,807	46,021	124,448	120,565	82,642	327,655
8-9	14,005	4,431	1,154	19,590[2]	124,617[2]	-	
9-10	433	65	245	743	33,455	-	

(Continued)

Table 2. Distribution of red salmon index catches by day and time period - Kvichak River, 1963.

Daily Period	Hourly Periods: Index Hours 2200-2300	2300-2400	0000-0100	3-hour Index	1200-2200	0100-1200	24-hour Total
10-11	382	79	36	497	11,190	-	
11-12	1,013	1,179	5	2,197	21,091	233	23,521
12-13	228	610	179	1,017	1,554	-	
13-14	7	123	14	144	140		
14-15	4,143	1,106	1,106	6,355	-	-	
15-16	280	2	536	818	0	-	
TOTALS	347,336	519,230	475,419	1,341,985	791,139	1,508,247	3,024,671

1/ Fyke net with 8.5' spread used. Counts expanded by factor of 1.059 to estimate catch with 9.0' net.

2/ Counts with upper cell only. Counts expanded by factor of 197.62% (seasonal relationship between upper and lower cell counts).

Table 3. Red salmon smolt catch ratios between time periods - Kvichak River, 1963.

	Index Hours						
	2200-2300	2300-2400	0000-0100	3-hour Index Catch	1200-2200	0100-1200	24-hour Catch
Seasonal Catch by Time Period	347,336	519,230	475,419	1,341,985	747,679*	1,508,247	3,024,671
Seasonal 3-hour Index Catch for Corresponding Days	1,341,985	1,341,985	1,341,985	1,341,985	1,335,630	1,112,700	1,112,700
Seasonal Ratio Between Index & Time Period Catches	0.2588	0.3869	0.3543	1.0000	0.5598 1/	1.3555 2/	2.7183 3/

* May 30-31 catch of 43,460 omitted from total since no 3-hour index catch is available on that date for comparison.

1/,2/,3/ - These superscripts are used in Table 4 to indicate which of these ratios were used for interpolation.

Table 4. Calculated red salmon smolt daily catches and index points - Kvichak River, 1963.

Date	Catch				24-hour index points	
	2200-0100 3-hr. index	1200-2200	0100-1200	24-hour Total	Daily	Accumulative
May 16-17	9	37	(12)[2]	58	.002	.002
17-18	-	-	-	(79)[1]	.002	.004
18-19	42	0	(57)[2]	99	.003	.007
19-20	3	0	(4)[2]	7	.000	.007
20-21	-	-	-	(7)[2]	.000	.007
21-22	-	-	-	(7)[2]	.000	.007
22-23	-	-	-	(7)[2]	.000	.007
23-24	-	-	-	(7)[2]	.000	.007
24-25	109,797	122,738	(148,829)[2]	381,364[3]	11.439	11.446
25-26	-	-	-	(236,034)[4]	7.080	18.526
26-27	38,507	0	(52,196)[2]	90,703	2.721	21.247
27-28	788,925	53,009	765,680	1,607,614	48.219	69.466
28-29	146,053	152,748	504,739	803,540	24.101	93.567
29-30	36,243	55,025	7,809	99,077	2.972	96.539
30-31	(38,818)[5]	43,460	0	82,278	2.468	99.007
31-June 1	0	120	16	136	.004	99.011
1-2	764	31	1,362	2,157	.065	99.076
2-3	30,909	10,961	(41,897)[2]	83,767	2.513	101.589
3-4	116	25,954	(157)[2]	26,227	.787	102.376
4-5	3,799	892	(5,150)[2]	9,841	.295	102.671
5-6	14,070	1,135	145,766	160,971	4.828	107.499
6-7	16,939	12,417	(22,961)[2]	52,317	1.569	109.068

(Continued)

Table 4. Calculated red salmon smolt daily catches and index points - Kvichak River, 1963 (continued).

Date	Catch				24-hour index points	
	2200-0100 3-hr. index	1200-2200	0100-1200	24-hour Total	Daily	Accumulative
7-8	124,448	120,565	82,642	327,655	9.828	118.89[illegible]
8-9	19,590	124,617	(26,554) 2/	170,761	5.122	124.01[illegible]
9-10	743	33,455	(1,007) 2/	35,205	1.056	125.07[illegible]
10-11	497	11,190	(674) 2/	12,361	.371	125.44[illegible]
11-12	2,197	21,091	233	23,521	.705	126.15[illegible]
12-13	1,017	1,554	(1,379) 2/	3,950	.118	126.26[illegible]
13-14	144	140	(195) 2/	479	.014	126.28[illegible]
14-15	6,355	-	-	(17,275) (3)	.518	126.80[illegible]
15-16	818	0	(1,109) 2/	1,927	.058	126.85[illegible]
	1,380,803			4,229,431		

1/, 2/, 3/ - These superscripts refer to ratios given in Table 3.

(1) The 24-hour catch for May 17-18 was calculated by averaging the catches on the bracketing nights.

(2) May 20-21 through May 23-24 were arbitrarily given the low 24-hour catch of May 19-20 as water temperatures were 28-35° F. during this period and no signs of migration were evident.

(3) Although the May 24-25 catch is based on fishing data from only two hours, the 381,364 catch calculated from this data is used. From visual observations of the migration during parts of this day when the net could not be fished it was estimated that the 24-hour migration was at least 10 index points.

(4) As temperatures during May 25-26 were 38° F., the estimate of the catch for this day was calculated by averaging the bracketing nights (when the water temperature was 36° F. for each night).

(5) This missing index period catch was calculated by averaging the results obtained by using the reciprocals of ratio 1/ (1 / 0.5598) on the 1200-2200 catch and ratio 2/ (1 / 1.355) on the 0100-1200 catch.

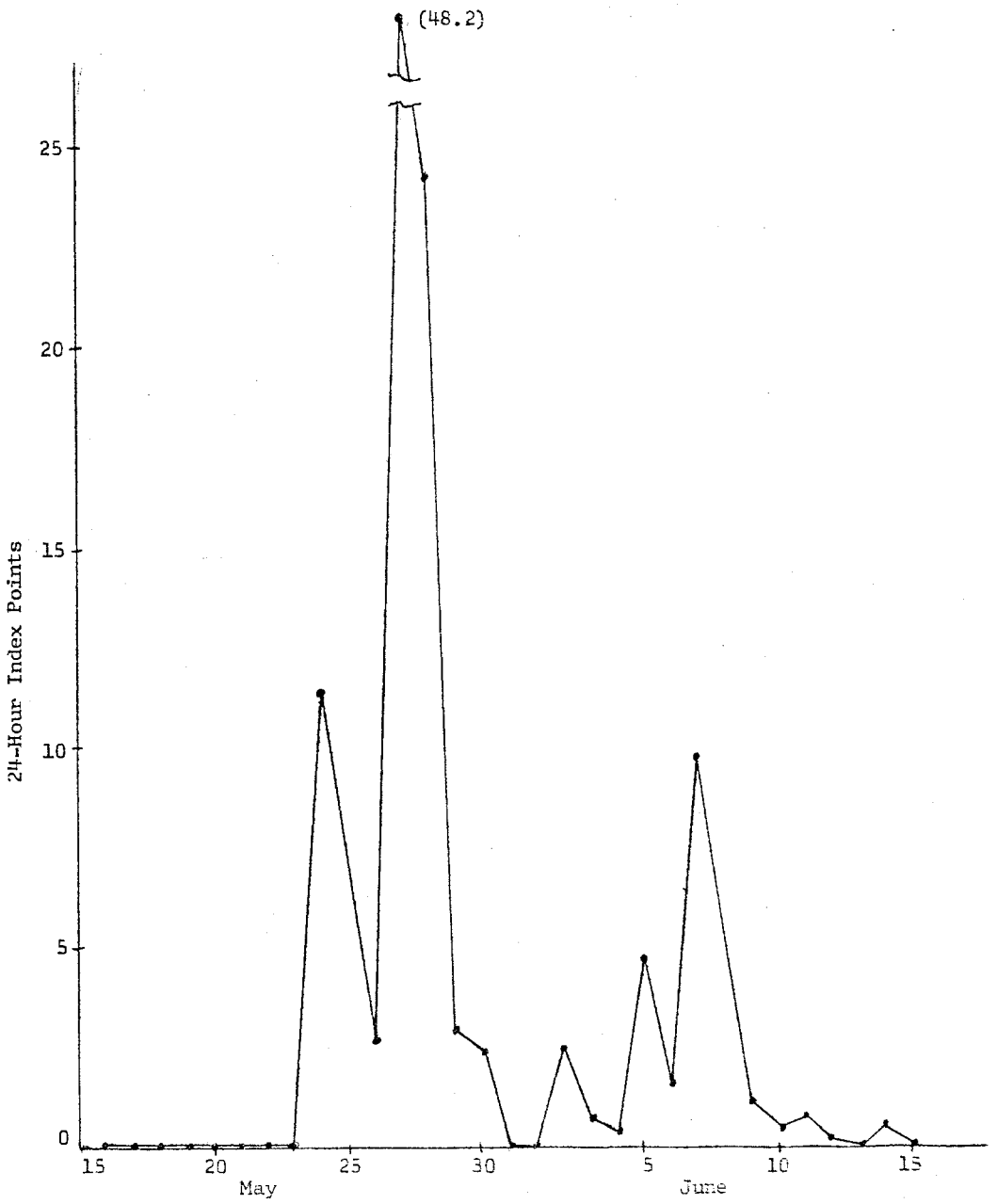

Figure 2. Daily index catches of red salmon smolt - Kvichak River, 1963.

Age, Size, and Condition of the 1963 Smolts

Age determination is important in the smolt enumeration because the time red salmon stay in freshwater may vary sharply between brood years. In the Kvichak system, length (snout to tail fork) measurements form the basis for separating Age I smolt from Age II smolt, as the Age II smolt are usually distinctly larger. However, in the length frequency distribution, the lower part of the Age II smolt length frequency curve may partially overlap the upper part of the Age I smolt length frequency curve. Scale analysis is used to determine the point of age separation for this overlapping portion of the length frequency distribution.

All length measurements collected in 1963 were from live smolts anesthetized in MS 222 (Tricaine Methanesulphonate) solution. One or more 1-pound samples were randomly taken each night from the fyke net catches during photo-electric counter calibration periods (2200-2300 and 0000-0100). Afternoon length samples were taken when the run was heavy enough to enable calibration during this part of the day. From previous year's observations, no significant length differences have been observed between day and night samples; therefore, all length frequency samples for each 24-hour period were combined. These length frequency samples were then weighted by catch size for that period (see last section on general procedures-length frequencies) and combined to produce Table 5, the seasonal weighted length frequency distribution. This distribution is plotted in Figure 3.

During the season, while taking length measurements, scale samples were also taken from approximately 5-10 fish per night in the intermediate size range (80-90 mm). Ages of smolt from the overlapping section of the length frequency distribution curve were used to arrive at the separation point of 87.5 mm. When this separation point was applied to the weighted length frequency distribution, a calculated 2.68 percent of the smolt were Age I and 97.32 percent were Age II smolts. The weighted length frequency distribution was also used to calculate the mean length of 83.32 millimeters for the Age I smolts and 98.34 millimeters for the Age II smolts.

Smolt condition studies have not been given uniform treatment in past reports. Consideration of mean length and weight, when calculated separately are not a true measure of condition. The two methods of determining condition commonly used in smolt studies are (a) yearly comparisons of mean weight in grams for a standard series of length groupings; and (b) $K = (\text{grams mean weight}) (10^5) / (\text{mm mean length})^3$ for a standard series of length groupings. Neither method has been maintained for the Kvichak River smolts.

Four condition samples were taken during the 1963 smolt season to which both methods listed above were applied and the results are summarized in Table 6. Weighting by smolt catch distribution gives a seasonal mean weight and mean K (condition factor) value for each 3 mm size groupings. Further weighting by length-frequency distribution is needed to produce the total mean seasonal weight and condition values for each age group. Age I smolts had a mean weight of 4.78 grams and mean K value of 0.817. Age II smolts had a mean weight of 7.49 grams and a mean K value of 0.780.

Table 5. Red salmon smolt weighted length frequency distribution - Kvichak River, 1963.

One Check		Two Check	
mm length	Weighted number of smolt	mm length	Weighted number of smolt
63	791	88	45,124
68	2,508	89	70,818
72	152	90	89,964
75	1,836	91	148,225
76	985	92	199,739
77	389	93	294,804
78	981	94	280,940
79	4,153	95	259,323
80	7,262	96	352,247
81	7,981	97	229,734
82	6,826	98	342,956
83	3,100	99	219,169
84	28,268	100	284,514
85	8,125	101	175,035
86	22,780	102	189,199
87	17,201	103	208,701
		104	162,926
		105	78,752
TOTAL	113,338	106	106,256
		107	68,919
		108	82,152
Percentage of run: 2.68		109	74,831
Mean length: 83.32 mm.		110	66,051
		111	24,962
		112	29,361
		113	27,838
		114	1,506
		115	1,751
		116	296
		TOTAL	4,116,093
		Percentage of run: 97.32	
		Mean length: 98.34 mm.	

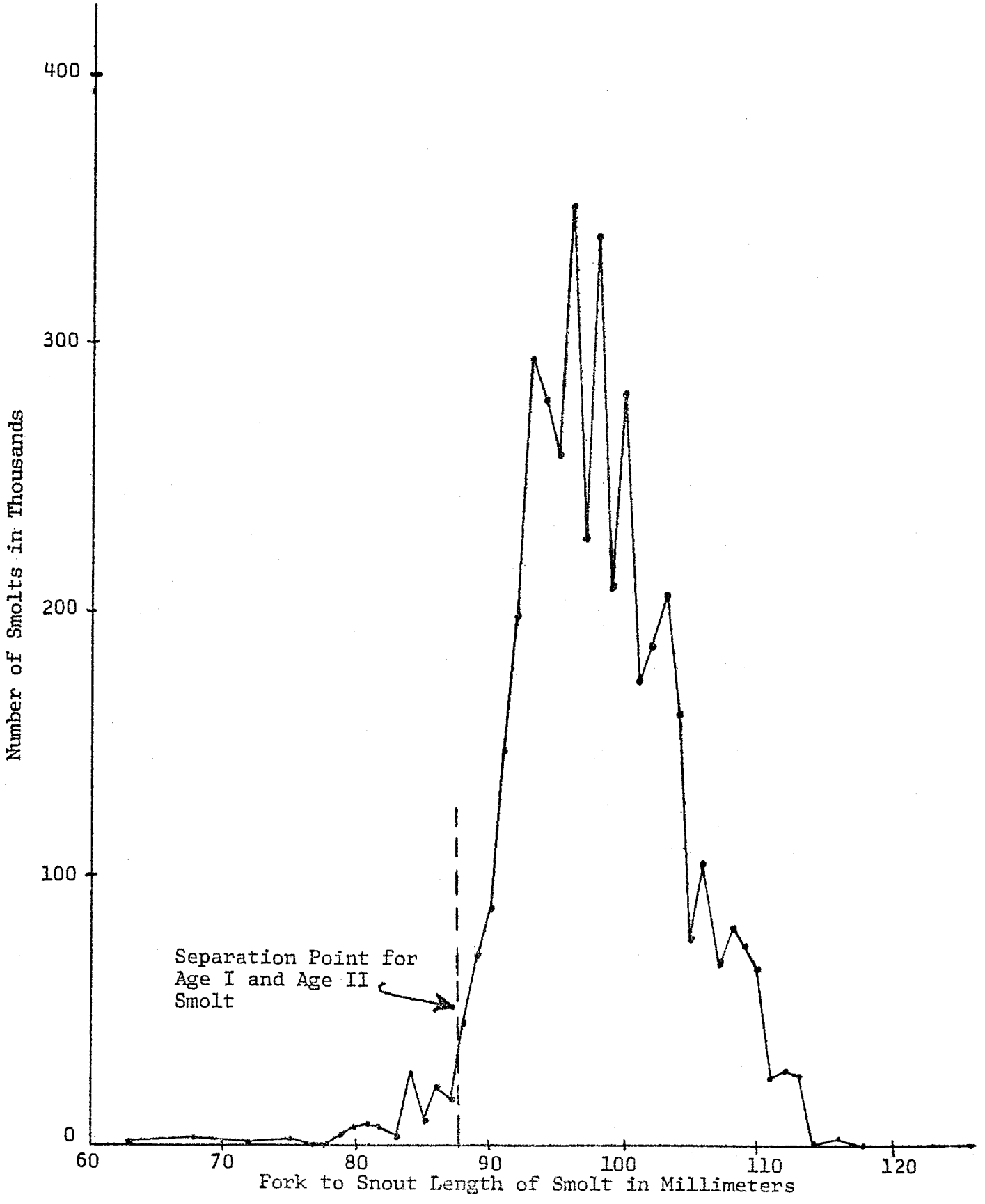

Figure 3. Red salmon smolt seasonal weighted length frequency distribution - Kvichak River, 1963.

Table 6. Red salmon smolt condition summary, Kvichak River, 1963.

Length Groupings in Millimeters	Condition Sample #1 Period 5/16-28 Index Catch: 2,315,986		Condition Sample #2 Period 5/28-6/2 Index Catch: 987,188		Condition Sample #3 Period 6/2-6/7 Index Catch: 333,123		Condition Sample #4 Period 6/7-6/16 Index Catch: 593,134		Weighted by Seasonal Catch		Weighted by Length Frequency	
	Mean wt. in grams	K*	Mean Wt. in grams	K*	Mean Wt. in grams	K*	Mean Wt. in grams	K*	Mean Wt. in Grams	Mean K*	Weighting Factor	Weighted Averages
75-77					3.50	0.797	3.10	0.735	3.24	0.757	.0588	(Age I)
78-80							4.60	0.898	4.60	0.898	.1094	4.78 gms.
81-83							4.40	0.828	4.60	0.898	.1580	
84-86					5.00	0.814	4.90	0.787	4.94	0.797	.5220	K = .817
87-89			4.80	0.717	5.85	0.873	5.40	0.782	5.17	0.764	.1800 1/	
90-92	6.00	0.771	5.99	0.784	5.87	0.774	5.87	0.784	5.98	0.776	.1064	(Age II)
93-95	6.70	0.802	6.45	0.774	6.33	0.767	6.70	0.807	6.61	0.793	.2028	
96-98	6.96	0.749	7.01	0.773	6.71	0.733	6.92	0.761	6.95	0.755	.2246	
99-101	7.77	0.782	7.72	0.781	7.57	0.891	7.72	0.774	7.74	0.789	.1649	7.49 gms.
102-104	8.68	0.792	8.50	0.780	8.45	0.779	8.60	0.780	8.61	0.786	.1363	
105-107	9.51	0.796	9.42	0.795			9.70	0.821	9.52	0.800	.0617	K = 0.780
108-110	10.08	0.783	10.15	0.788	10.65	0.822	10.50	0.811	10.20	0.791	.0542	
111-113	10.70	0.762	10.00	0.731			10.50	0.747	10.49	0.752	.0200	
114-116	10.60	0.715	11.43	0.757	10.90	0.717			10.85	0.727	.0009	

1/ Weighting factors of 0.1518 for the 87 mm Age I smolt and 0.282 for the 88-89 mm Age II smolt combined yield 0.1800 for the 87-89 mm smolt.

Evaluation of Kvichak River Smolt Data Since 1955

Table 7 presents a summary of the smolts produced from each parent escapement to the Kvichak system since 1952. The magnitude of smolt migrations are based on calculated 24-hour catches at the index site. The right hand column shows the ratio of smolts to parent escapement. It should be noted that due to the indexing procedures, this is not an absolute freshwater survival value but rather a relative index of survival to smolt stage. Table 8 presents mean lengths and weights for these smolts, with the data being graphed in Figure 4.

Although data is available for only eight complete years, these relative survival index values show that the efficiency of smolt production per spawner to increase as the magnitude of the parent escapement increases. This trend can be further demonstrated by comparing the mean relative smolt survival indexes produced by the five years of under two million escapement with the three years of over two million escapement. The low escapement levels have a geometric mean relative survival rate of 0.140 while the higher years have a mean of 0.373 or better than twice as high a relative survival index. While it is true that one of the low escapements, 1955, had a high survival index and the intermediate escapement, 1957, had a low survival index, the general trend of the available data is toward a higher relative smolt survival per spawner for larger escapements. It may be theorized that the low relative survival index from the 1957 escapement was due to high mortality incurred by competition with or food depletion in the lake by the large smolt population produced by the 1956 spawning. Also, comparison of the relative survival indices for the 1956 and 1960 escapements indicates that the 1960 escapement was not as efficient in smolt production as that of 1956 although it was larger. It could be hypothesized that the progeny of the 1960 escapement had a higher mortality due to an excessive number of fry in the lake. However, there is not enough data to strongly support either of the last two statements. Apparent mortalities could be due to several different factors including variations in smolt indexing. No accurate statements about optimum escapement can be made on the basis of the available data, but the trend of changing spawner efficiency observed here could be a major factor in the development of dominant cycle years which have been characteristic of the Kvichak system.

A summary of weighted and smoothed length frequency distribution for Kvichak River smolts for 1955 through 1963 is shown in Figure 5. From this figure, the 1963 smolt catch is shown to have comprised the smallest size Age II smolts on record.

The mean length and weight of smolts compared to the magnitude of the migration is shown in Figure 6. (Note 3 years of missing weight data when length data was available). From this figure it is evident that for Age II smolts, a steady decrease in both length and weight is produced with increasing numbers of smolt in the migration. However, for the Age I smolts, no appreciable decrease in length or weight is evident in smolt catches of over 100,000 (3.0 index points). This suggests that in years of large abundance, competition among Age I smolts is not as severe as in the Age II smolts which spend one more year in the lake.

Table 7. Red salmon parent escapement and relative smolt production (fish in thousands) - Kvichak River, 1955-61.

Year	Parent Escapement	24-hour index catch 1-check	2-check	Total	Percent in age classes 1-check	2-check	24-hour index smolt Per Parent Escapement
1952	5,970	--(1)	242	--	--	--	--
1953	1,348	18	47	65	27.7	72.3	0.048
1954	241	30	9	39	76.9	23.1	0.162
1955	251	22	67	89	24.7	75.3	0.355
1956	9,443	3,267	2,778	6,045	54.0	46.0	0.640
1957	2,843	86	553	639	13.5	86.5	0.225
1958	535	61	10	71	85.9	14.1	0.133
1959	680	26	72	98	26.5	73.5	0.144
1960	14,630	1,131	4,116	5,247	21.6	78.4	0.359
1961	3,706	113	--(2)	---	--	--	--

(1) 1-check smolt from parent year 1952 migrated in 1954.

(2) 2-check smolt from parent year 1961 will not migrate until 1964.

Table 8. Average length and weight of red salmon smolt (fish in thousands) - Kvichak River, 1952-61.

Year of Parent Escapement	24-hr. index catch 1-check	2-check	Average length (mm) 1-check	2-check	Average weight 1-check	2-check
1952	--(1)	242	--	109	--	--(3)
1953	18	47	89	116	--(3)	--(3)
1954	30	9	92	120	--(3)	14.4
1955	22	67	96	114	7.3	--(4)
1956	3,267	2,778	84	99	4.6	7.6
1957	86	553	80	108	--(4)	10.3
1958	61	10	91	118	6.3	13.1
1959	26	72	93	110	6.8	9.9
1960	1,131	4,116	82	98	4.3	7.5
1961	113	--(2)	83	--	4.8	--

(1) 1-check smolt from parent year 1952 migrated in 1954.

(2) 2-check smolt from parent year 1961 will not migrate until 1964.

(3) Weight samples not taken.

(4) Weight samples inadequate.

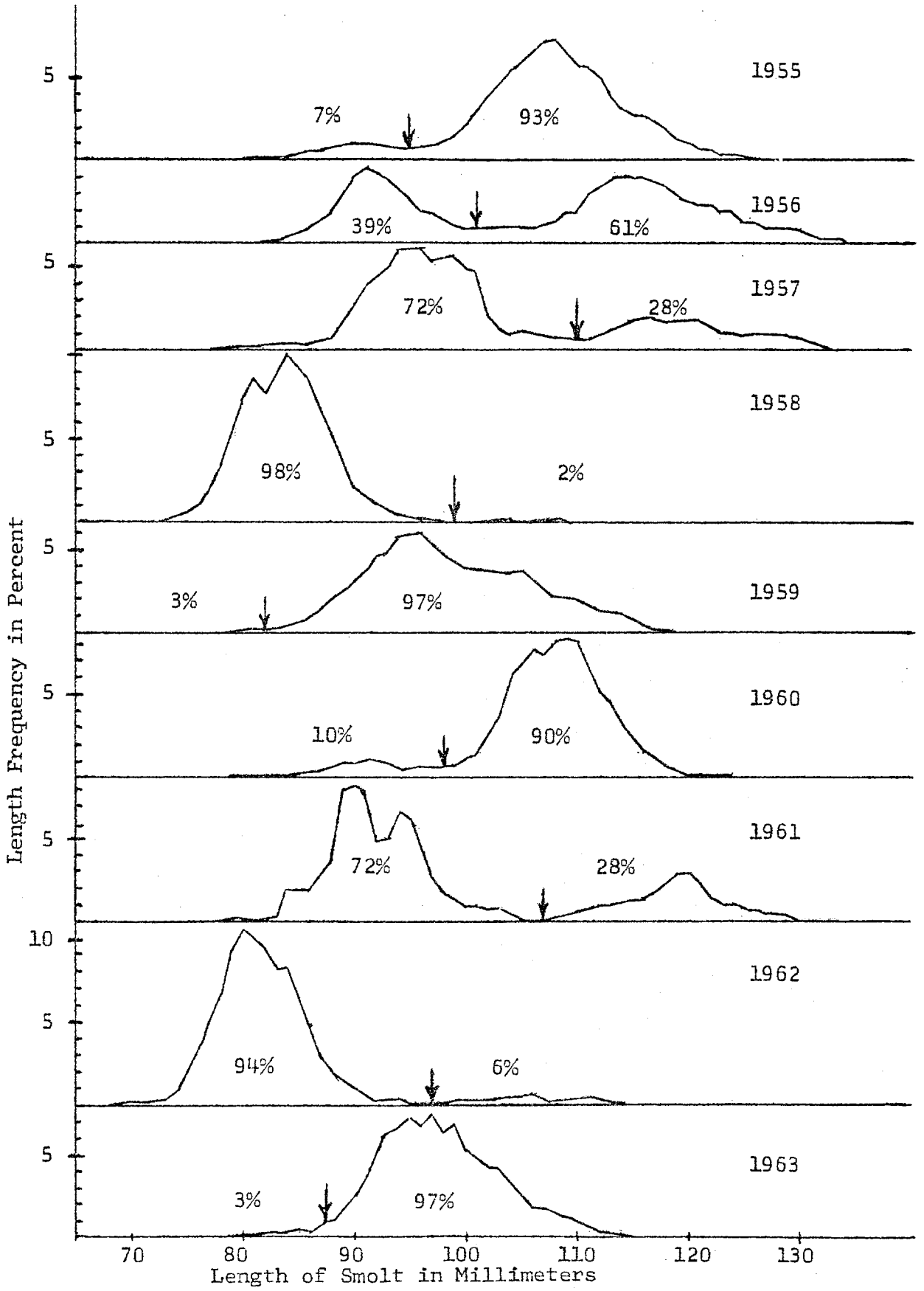

Figure 4. Red salmon smolt weighted length frequencies smoothed by moving averages of three (arrows separate Age I and Age II smolt) - Kvichak River, 1955-63.

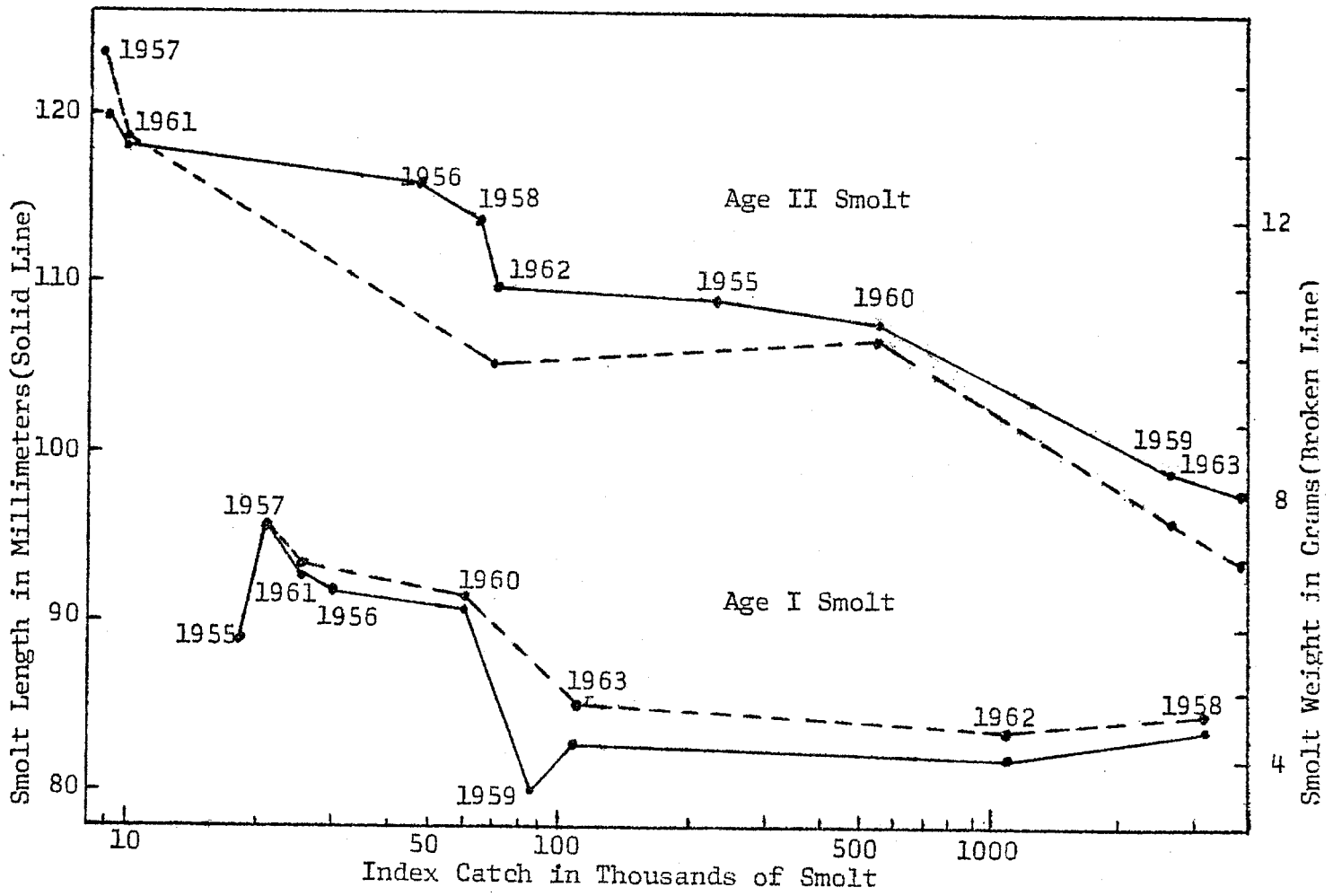

Figure 5. Red salmon smolt index catches and corresponding lengths and weights of smolt - Kvichak River, 1955-63.

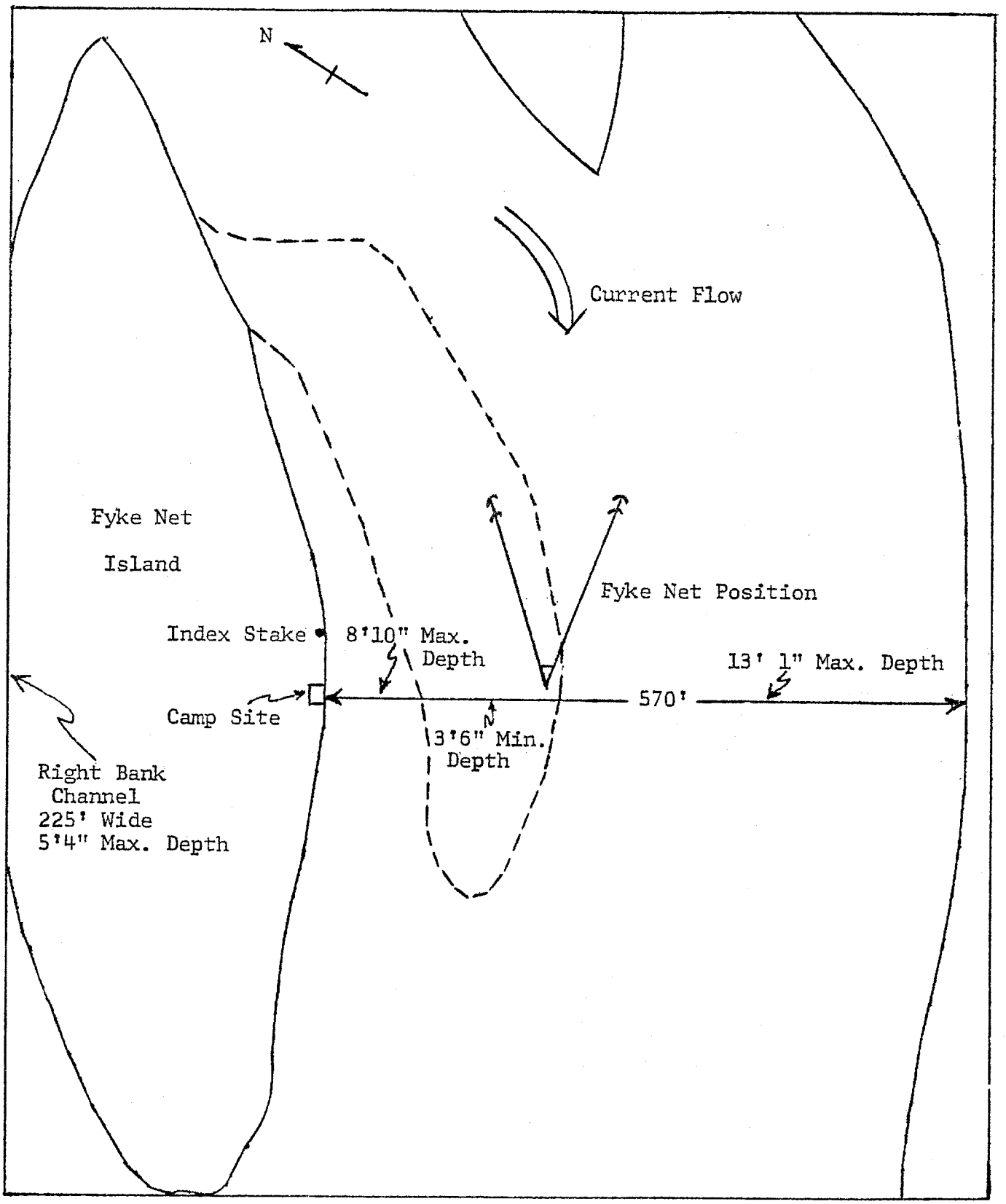

Figure 6. Location of index fishing site (four miles below outlet of Lake Iliamna) - Kvichak River, 1963.

In consideration of this data it should be pointed out that the effect of age, size, and condition of smolts on early marine survival may be of great significance, but has not been adequately studied. Other unknown but potentially significant factors which could greatly influence smolt survival after the time of indexing are the seasonal changes in river water level, salinity, beluga whale and other predation, etc.

Conclusions

The index method of fyke netting initiated in 1955 was continued in 1963 with two major exceptions: (1) photo-electric counters were used whenever possible; and (2) 24-hour fishing replaced the normal fishing of index hours (2200-0100 hours).

Excessive ice flow at the beginning of the smolt migration made some subjective treatment of the data necessary. However, this subjective treatment was kept as conservative as possible. The calculated 24-hour smolt index catch was 4,229,431 smolts or 126.9 index points, the highest on record. The catch was composed of 2.68 percent Age I smolts and 97.32 percent Age II smolts. Mean length, weight, and condition values for the Age I smolts were 83.32 mm, 4.78 grams and 0.817 respectively; mean length, weight, and condition values for the Age II smolts were 98.34 mm, 7.49 grams, and 0.780 respectively, the smallest values recorded for Age II smolts from this system. The calculated 3-hour index catch was 1,380,803 smolts or 72.19 3-hour index points.

A review of the available past data strongly suggests a general trend toward increased smolt production per spawner with increased escapements. There is not yet enough data available to definitely establish a level of optimum adult escapement. Although length and weight of Age II smolts are apparently depressed with increased escapement size (this is less apparent with Age I smolts), the relative smolt survival index has still generally increased. This would indicate that the rearing areas in the Kvichak system are not being over-utilized. Additional data will be necessary to determine the effects of various phenomena within a cycle. It is possible that even large escapements in years other than the main cycle year may be relatively unproductive. Smolt production from the 1961 escapement should shed some light on what happened to the progeny of the 1957 run, since both years followed an exceptionally large previous year's escapement. The actual returns from the 1960 escapement should help to indicate whether there was a smaller production for this year than for the smaller 1956 escapement. It should be pointed out that the reason for the high percentage holdover of Age II smolts from the 1960 escapement is not known. As is shown in Table 7, the percentage of Age I and Age II smolts produced is not apparently releated to the size of the parent escapement. Small escapements have also produced high percentages of Age II smolts.

General Procedures Used in Collection and Analysis of Data

Location of the fyke net site

The index fishing site is located approximately four miles downstream from the lake outlet. This site was found most favorable for several reasons. As shown in Figure 6 a large, gradually sloping gravel bar of appropriate depth is located

near mid-channel where water velocity maintains an ideal 3.5 ft per second. Such a sloping gravel bar is essential as river depth characteristically rise steadily during the smolt season and the net site must usually be moved farther up on the bar two or three times during the season to maintain the correct fishing depth of 3'10". An attempt is made to maintain the opening of the fyke net approximately abreast of the index stake located on the shore about 50 feet upstream from the camp site.

Setting and pulling of the net

Due to a rather unstable bottom of fine gravel, special care is needed to obtain a proper anchor set and avoid later dragging of the anchors. Two 75-100 pound yachtsman anchors tied in series are used on each line. A separate piece of line about 15 feet long should be tied from the upstream anchor to the bottom fluke of the downstream anchor. At least 150 feet of line is required for each anchor set. If line heavier than 3/4" is used for this, added water resistance will increase the chance of anchor drag.

The right hand bridle is attached via release rings and adjusting line as shown in Figure 7. The left hand bridle is attached directly to the adjusting line ring by a snap swivel. Adjusting lines are needed to maintain an equal angle of pull in both lines and prevent the fyke net from excess bagging at one wing.

Once the anchor and adjusting line are of proper length, the net is set in the following manner. The net is placed in the bow of the fyke net skiff with the bottom of the 4 x 4 foot frame over the port gunnel, and all lines are carefully sorted and placed to avoid tangle. The small skiff is tied behind the fyke net skiff. After all equipment is placed in the fyke net skiff, one man stands at the bow and one man operates the motor. The offshore float is picked up and snapped to the bow of the skiff. The skiff is then run slightly upstream and over to the inshore line, which is picked up with a gaff hook. With the boat still under power, the bow man retrieves both adjusting line rings and slips them over the bow holding peg, at which time the motor is shut off and tilted above water. The bridle snap and quick release ring are attached to the adjusting line rings. When all lines are double checked, the adjusting line rings are unhooked and the bow man holds one set of bridle lines in each hand. The other man holds the left wing spreader bar. At a given signal the left bridal line is thrown overboard and the bow man picks up the right wing spreader bar. He slides his grip down the bridle ropes, maintaining tension on the release mechanism. As tension comes to both spreader bars, both men release their grip and quickly slide the 4 x 4 foot frame over the gunnel. While the mid-ship man rapidly clears the net hoops, the bow man grabs the frame bridle and hangs on. The net frame is lifted off the bottom several times until it sets perfectly perpendicular to the current and eliminates any wing bagging. The boat is snapped to the left corner frame of the net and the quick-release line picked up and fastened to the right corner of the frame. The 18-inch attachment ring is then raised above water so the cod-end or photo-counting tunnel may be attached.

In pulling the net, the first procedure is to remove the cod-end or counting tunnel. The mid-ship man pulls the release line to collapse the net while the bow man holds the net frame. The net is pulled over the starboard gunnel (18" rings first) and the release line is retrieved to prevent tangle in the

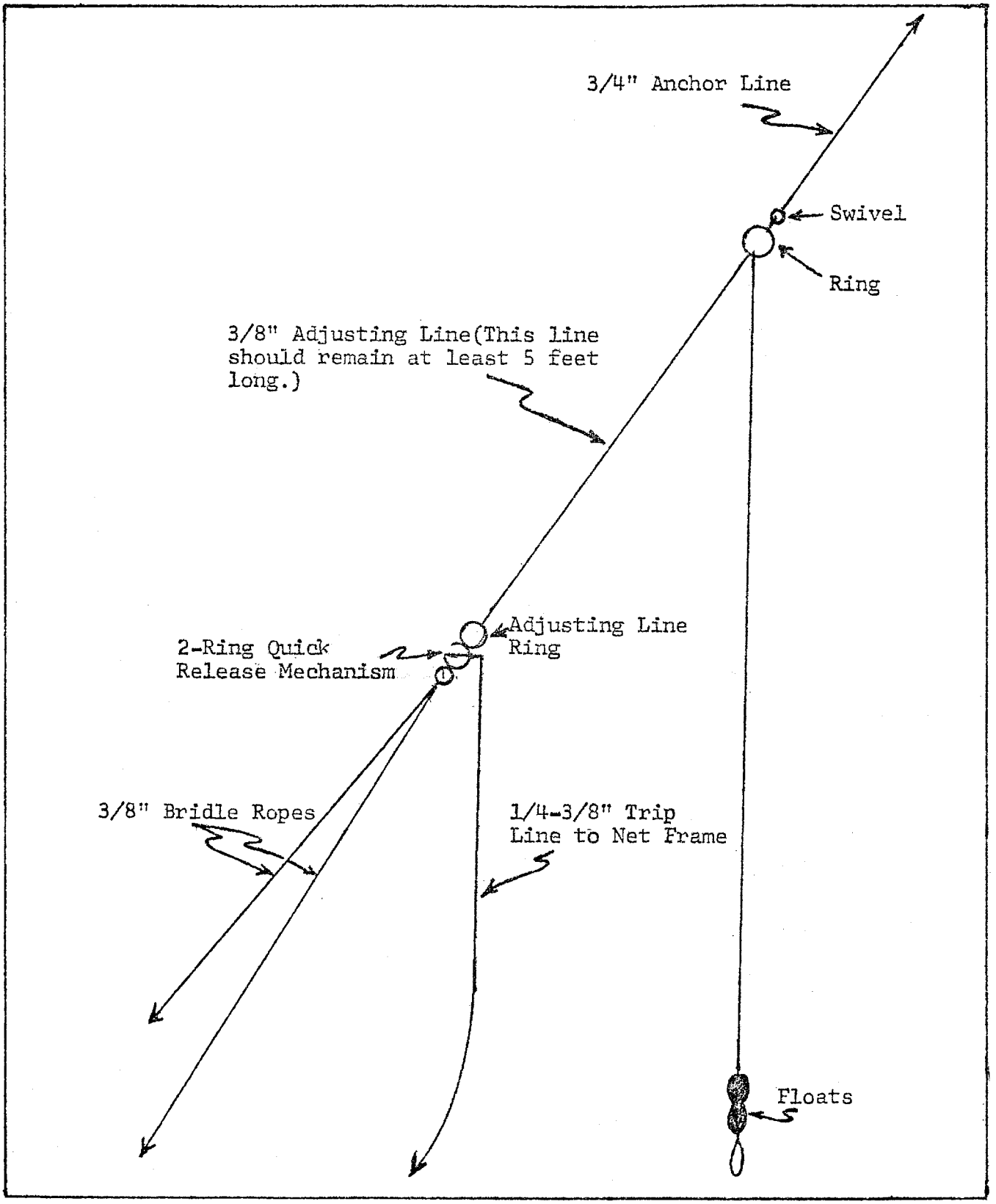

Figure 7. Right wing anchor line showing quick release mechanism - Kvichak River, 1963.

outboard. When the motor is started to take tension off the left wing bridle, the bow man brings in the left wing and unsnaps the ring. The net is then taken ashore and tied to posts to dry in an open position. It is best cleaned with a brush while still wet.

Both setting and pulling of the net may also be done with three men taking the operation easier.

Ice and debris problems

At the beginning of the smolt season, ice floes are frequently a problem on the Kvichak River. When ice is running in the river, the counters should not be used. Small ice floes which are caught in the net will quickly melt, but when larger pieces threaten, the net should be pulled. If ice is too thick to fish the net, every effort should be made to anchor a boat from the offshore line to make visual observations of smolts passing. This is better than no data.

When strong northeast winds blow down Lake Iliamna and a surf develops at the outlet, algal debris in the water becomes a problem. In these circumstances the debris will stick to the net webbing and if not constantly brushed will clog the net, severely reduce its catching ability, invalidate the data, and likely cause the anchors to drag. Although frequent brushing of the net will greatly help, the net should be periodically changed so that the bottom and lower side may be cleaned.

Normal fishing procedure and data processing

When catches are small and the net will not be left for periods of over 1/2 hour, or when ice is running in the river, the net may be fished by using the unmodified cod-ends. In this case the ring line is used to raise the attachment rings, and holding the ring above the water to prevent any smolts from passing, the cod-end is attached and lowered. The time when the rings were first brought above the surface is noted and recorded in a field book. When catches of about 20 pounds have accumulated in the cod-end, or at least every one-half hour, the cod-end should be raised, the time noted and recorded, the cod-end removed and another cod-end attached before the rings are again lowered and the time recorded. The cod-end is emptied into a screen mesh weighing basket immersed in a wash tub two-thirds full of water. If the catch is less than two or three pounds, it should be counted. Larger catches are weighed by lifting the screen basket out of the tub and hanging it from a scale attached to a davit. Five seconds are allowed for the water to drain off, at which time the weight is noted and recorded. The basket is again set into the water and a random one-pound sample scooped out and put into a pail of water before the smolt basket contents are released over the side. The one-pound smolt sample in the pail may be counted and released or saved for length frequency or condition samples. If for some reason the counter cannot be used and during this time the migration becomes too heavy for the crew to keep up with the cod-end catch, the cod-end should be fished intermittently with all times carefully noted and recorded.

Photo-electric counter operation and calibration

Before operation, the photo cell units in the counting tunnel should be checked

to see that they are free of condensation, tightly sealed, and closely aligned. The two counters (with rheostats on full power) are placed in the special fyke net skiff box with 12 volt battery and transformers. All electrical connections are made and the counter tested with a one-fourth inch metal rod or pencil. It is very critical that before the fyke net is set, the tunnel is put on the 18" attachment ring and checked to see that no spaces large enough for smolt passage occur between the net ring and tunnel. When the net is set and the tunnel is to be put on, it is carefully lowered by the attachment lines. The counters are then turned on and the photo cells checked by use of a stick with a one-quarter inch metal rod 8-10" long attached. This rod is worked up and down in the middle of the tunnel aperature to break the light beams. The counting tunnel should also be adjusted with the line so that it is several inches above the river bottom and counts approximately equal numbers of smolts on each cell. The photo-counters are then reset (preferably when no fish are passing). Counters are checked, counts recorded, and reset every hour on the hour. During low migration levels with no ice or algal debris, longer periods may be missed, but the 1200-2200, 2200-2300, 2300-2400, 0000-0100, and 0100-1200 hour period units should always be observed. Batteries are frequently checked and changed for recharging after a maximum of 8 hour's operation.

Proper photo-counter calibration requires an alert, well coordinated crew of three people, although it can be accomplished by two when the run is light. Calibration is done during the hours of 2200-2300, 0000-0100 and one afternoon hour when the run is heavy enough to obtain 200 counts per hour. The object is to determine the number of smolts passing and rate of passage for a pre-established total count on the counter. Procedure of calibration will be given here as a running account, using the data from the May 30, 1963, 0000-0100 hours calibration as a suggested sample of the procedure for field and fyke net log entering.

Operator #1 — Recorder and time keeper, is positioned in the bow of the fyke net skiff to read the counters. He is equipped with a field book, wrist watch, and flashlight or shaded lantern.

Operator #2 — Tunnel lifter and smolt weigher is positioned mid-ship. He is equipped with a strong back.

Operator #3 — Cod-end zipperer, attacher, and sample weigher is positioned mid-ship and to the stern. He is equipped with a headlight, extra cod-end pins, a fry basket, and 3 - lb. scale.

The example procedure is as follows: Operator #1 checks his watch and when the calibration hour (0000) arrives he records the upper cell (2450) and lower cell (1190) counts since the last check (2300 hrs.). He resets the counters and leaves them running until the crew is in position. Then he reads off the seconds to go until the next completed minute (0002) approaches, at which time he yells "Go" and records the counts (36-8) before Operator #2 has brought the tunnel above the water surface. When Operator #3 has attached the zippered cod end to the ring, Operator #2 immediately yells "Down" and lowers the tunnel. At this signal Operator #1 starts his stopwatch and punches both counter reset buttons. He then looks at his wristwatch and records the time of this start (0002-10). Operator #1 watches and listens to the counter, counting out each

click (each 10 counts) heard. When the counters approach 20 clicks (200 counts), Operator #2 and #3 take their positions. As the 20th click is reached, Operator #1 yells "Up", and punches his stopwatch and records the counter tallys (150-50). Only the digit wheels are read, then multiplied by 10 in order to facilitate recording. The fact that the actual total count may range from 200 to 209 is considered insignificant. During this time Operator #3 has removed the full cod-end and places it in the tub, where he will open the zipper. Operator #2 lowers the tunnel, and when submerged yells "Down". Operator #1 then punches the reset buttons and records the time (0002-54). While operator #2 weighs the catch and Operator #3 takes and counts a one-pound sample, Operator #1 records the stopwatch time (18 min. 40 sec.) for the catch. He also receives and records the number of pounds (17) of the catch and the number of fish (61) per pound. If the fish are to be saved for a length-frequency (LF 63-11) it should be noted. When this is done and all operators are ready for another calibration, Operator #1 again begins a countdown to the nearest minute (0027-0), yells "Go" and records the time and counter numbers (30-10). Procedures continue as before, however in the illustrated case the 200 count was not reached before the end of the hour. When 0100 hours arrived, the number of pounds (6) and number of fish (61) per pound were recorded and the calibration ended.

This data would appear in the field book as below:

2400 - 0	2450 - 1190	
0002 - 0	36 - 8	
- 10	0 - 0	
18' - 40"	150 - 50	17 lbs., 61/lb., LF 63-11
0020 - 54	0 - 0	
0027 - 0	30 - 10	
- 10	0 - 0	
32' - 50"	51 - 13	6 lbs., 61/lb.

Upon arriving back at the camp site or scows, the field data should be recorded in the fyke net log. A sample page showing method of filling out for both cod end and photo-electric methods is given in Table 9. Note that the previously given hour of calibration is included here.

Length Frequency Measurements

A random one pound length frequency sample should be taken from the cod end catches during every hour of calibration. These fish are kept in a 3-gallon pail of water and either put in a live-box for measurement the next day or preferably measured the same evening. Equipment needed is a measuring board (consisting of a millimeter rule glued to a smooth flat board, and with a squared wood nose block glued at the zero millimeter mark), and a length frequency form as shown in Table 10. Also needed is a 3-gallon pail of mixed anesthetic and a 3-gallon pail of fresh water, as length frequency measurements should be done with anesthetized fish. The suggested procedure for anesthetizing is to use MS 222 mixed in a stock solution (three grams per quart) and stored in a darkened bottle. This stock solution is then mixed one part to 100 parts of water for use, or 100 milliliters per 3-gallon pail of water. The diluted MS 222

Table 9. Fyke net log.

Form FG-141

Location Kvichak River Year 1963

Date	Site	Net	Fishing Time Set	Pulled	Min.	Counted Upper	Lower	Total	Cod End Catches Weight	No./Lb	Catch	Remarks Water Temp., Samples, Etc.
5/29	I	2	1630-0	1635-0	5-0				8	55	440	
			1640-0	1644-0	4-0				13	61	793	
		2	1703-0	1800-0	57-0	649	1100	1749				Photo-unit checked-O.K.
				1823-0	23-0	101	152	253				Unit off for batt. charge.
		2	1826-16	1900-0	33-44	32	43	75	6	67	402	Sample 63-9
			1900-20	2000-0	60-0	72	91	163				
				2100-0	60-0	186	238	424				
				2200-0	60-0	189	235	424				W. T. = 40.0°F
				2243-0	43-0	760	500	1260				
			2243-13	2247-15	4-02	140	60	200	18	59	1062	Sample 63-10
			2247-18	2251-0	3-42	350	210	560				
			2251-15	2253-10	1-55	140	60	200	17	60	1020	
			2253-15	2256-0	2-45	140	90	230				
			2256-15	2300-03	3-48	150	50	200	16	60	960	
			2300-05	2400-0	60-0	2450	1190	3640				
				0002-0	2-0	36	8	44				
5/30			0002-10	0020-50	18-40	150	50	200	17	61	1037	Sample 63-11
			0020-54	0027-0	6-06	30	10	40				
			0027-10	0100-0	32-50	51	13	64	6	61	366	
				0200-0	60-0	306	154	460				Battery change.
				0300-0	60-0	211	135	346				
				0400-0	60-0	99	96	195				
				0500-0	60-0	168	169	337				
				0600-0	60-0	9	10	19				
				0700-0	60-0	0	0	0				
				0800-0	60-0	0	0	0				

Table 10. Smolt length-frequency form.

FG-140

Location Kvichak River Site Index Date 6/2-3 Time ____ Sample #63-13 #63-14 Weight ____

Mm.	Tally		Tot.	Wt.Tot.	Mm.	Tally		Tot.	Wt.Tot.
<50	#63-13	#63-14			96	𝍸 𝍸 //	////	16	.3488
50					97	𝍸 ///	////	12	.2616
51					98	//	//	4	.0872
52					99	𝍸 //	/	7	.1526
53					100	𝍸		5	.1090
54					101		/	1	.0218
55					102	/		1	.0218
56					103		/	1	.0218
57					104				
58					105		/	1	.0218
59					106	/	//	3	.0654
60					107				
61					108		/	1	.0218
62					109				
63					110				
64					111				
65					112				
66					113				
67					114		/	1	.0218
68					115				
69					116				
70					117				
71					118				
72					119				
73					120				
74					121				
75					122				
76					123				
77					124				
78					125				
79					126				
80		//	2	.0436	127				
81		/	1	.0218	128				
82		/	1	.0218	129				
83					130				
84		/	1	.0218	131				
85					132				
86					133				
87					134				
88		//	2	.0436	135				
89		////	4	.0872	136				
90	/	///	4	.0872	137				
91	/	𝍸 /	7	.1526	138				
92	////	𝍸 //	11	.2398	139				
93	////	𝍸 /	10	.2180	140				
94	𝍸 ///	𝍸 𝍸 /	19	.4142	>140				
95	𝍸 𝍸	𝍸	15	.3270	Totals	63	67	130	

should not be kept more than two days. For measuring smolt, approximately 10-12 fish at a time are scooped from the pail and put in the anesthetic. When anesthetized, their lengths are read in millimeters from snout to tail fork and the lengths are then tallied. The measured fish are either returned to a pail of fresh water for recovery and release, or laid in formalin in a flat enamel pan for at least 12 hours prior to being bottled for preservation. From measurement of smolts preserved in formalin for 12 hours and in ten percent formalin for approximately 4 months, a mean shrinkage in length of 3.7 percent was found.

Scale Samples

Scales from approximately five smolts in the intermittent size groups should be taken with each length frequency sample. These scales (approximately 6-8) are scraped with a scalpel blade from a mid-lateral area between the dorsal and adipose fin. They are then smeared on a glass slide and separated with needle or scalpel point. The slides have been previously prepared by placing a section of masking tape around each end, so that sample and length data may be recorded on the end tape. No cover glass is used, as the masking tape will adequately separate the slides. This method of using one slide per smolt and no cover slip has been found to greatly expedite the taking of smolt scales in the field.

Condition Sample

Condition samples should be made approximately every four days during the major portion of the smolt migration. These studies are always done with live smolts which are later preserved. The procedure is to obtain a random 2-pound sample from the first evening calibration check. This sample is taken back to the scows where proper light and a large working table are available. The equipment needed is: (1) 20 shallow containers with lids and screens one-quarter inch from the bottom; (2) a balance (preferably a triple beam); (3) forceps; (4) a smolt measuring board; (5) an enamel pan with formalin; (6) a pail of MS 222 solution; and (7) length frequency and condition sample forms. The procedure is to first re-weigh two pounds of smolts and place them in one lot into the MS 222. When they are well anesthetized, each fish is measured and placed in the appropriate length-labeled container until 10 fish of each 3-millimeter length group are obtained. The container lids should be constantly closed to prevent dehydration of the smolts. When the two-pound length frequency sample is completed, each container is weighed. The fish are then removed with forceps, put in the formalin with the surplus fish, and the empty container and lid weighed to obtain the exact weight of the drained fish. Scale samples should not be taken until the fish are weighed and being put into formalin. All data is recorded on the condition sample form (Table 11). Completion of calculations on these condition sample sheets may be done after the season.

Weather Observation Records

Daily weather records are kept during the fyke net and tower counting seasons. Time of observation should be kept uniform, preferably at 2000 hours, which has been found most convenient and indicative of conditions at the beginning of the evening migration. The maximum-minimum thermometer is located in an open wooden

FG-139 Table 11. Smolt condition - sample form.

Condition Sample 4/4
Length Frequency #63-23

Location Kvichak River Site Index Date 6/8/63 Time 2200

Anesthetized [X] Preserved [ ]

1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
Mm.	Tally	1x2	$\frac{\Sigma 3}{\Sigma 2}$	Grams Cont. + Fish	Grams Cont.	$\frac{5-6}{\Sigma 2}$	$K=7/4^3 \times 10^5$	Mm.	Tally	1x2	$\frac{\Sigma 3}{\Sigma 2}$	Grams Cont. + Fish	Grams Cont.	$\frac{5-6}{\Sigma 2}$	$K=7/4^3 \times 10^5$
								96	////	384					
								97	//	291					
								98	///	294					
Σ								Σ	10	969	96.9	168.9	99.3	6.92	0.761
66								99	////	396					
67								100	///	300					
68								101	///	303					
Σ								Σ	10	999	99.9	154.0	76.8	7.72	0.774
69								102							
70								103	///	809					
71								104	/	104					
Σ								Σ	4	413	103.3	104.9	70.5	8.60	0.780
72								105	//	210					
73								106							
74								107	/	107					
Σ								Σ	3	317	105.7	111.5	86.0	9.70	0.821
75	/	75						108							
76								109	/	109					
77								110							
Σ	1	75	75.0	76.1	73.0	3.10	0.735	Σ	1	109	109.0	77.3	66.8	10.5	0.811
78								111							
79								112	///	336					
80	/	80						113							
Σ	1	80	80.0	79.4	74.8	4.60	0.898	Σ	3	336	112.0	112.8	81.3	10.5	0.747
81	/	81						114							
82								115							
83								116							
Σ	1	81	81.0	71.2	66.8	4.40	0.828	Σ							
84	/	84						117							
85	///	225						118							
86	////	344						119							
Σ	8	683	85.4	136.8	97.0	4.90	0.787	Σ							
87								120							
88	////	440						121							
89	///	267						122							
Σ	8	707	88.4	133.3	89.9	5.40	0.782	Σ							
90	////	450						123							
91	//	182						124							
92	///	276						125							
Σ	10	908	90.8	136.8	78.1	5.87	0.784	Σ							
93	////	372													
94	//	188													
95	////	380													
Σ	10	940	94.0	149.0	82.0	6.70	0.807	Σ							

box nailed to a shading tree beside the river at the scow site. Wind direction, velocity, and cloud cover are estimated at the scow site. The water-level gauge is located downstream from the river landing at the scow site just opposite a 2 inch by 4 inch stake with a nail bench mark. A metal stake is driven in the water just offshore, and a rule taped to the stake. The stake is calibrated with the bench mark by placing a sighting level on the nail bench mark and finding the vertical distance between the bench mark and the "zero" reading on the gauge. Water levels are usually taken in inches to the nearest tenth. Water temperatures are taken at the river surface by wading out from the water level stake until knee deep in water. Every night the fyke net is fished, water temperatures should also be taken at 2200 hours from the surface at the index site and recorded in the fyke net log. Location of water temperature readings should always be listed under remarks in the weather form if the index site reading is used. A sample weather and river observation form is shown in Table 12.

Enumeration Analysis

Once the fyke net log has been completed and checked for errors, the first procedure in analysis of enumeration is to determine the counter conversion ratios. This is begun by transcribing the fyke net counter data into tabular form as in Table 1. In order to determine whether the conversion ratios should be stratified by magnitude of passage rate and/or by seasonal timing, several graph plots are of aid. Figure 1 shows a plot of counting rates on passage rates. If counter efficiency were to significantly change with increasing passage rate, stratification by different levels of passage rates should be used to form two or more separate lines. A graph of changes in counter efficiency during the season (not included here) should be made to determine if the ratios need to be stratified by seasonal timing. When this is completed, daily conversion ratios are examined to see if they fluctuate as daily units enough to be treated separately, or whether one seasonal ratio may be used. In general, the least necessary stratification of the conversion factor is considered desirable. Although in the past, the counter data has been treated subjectively, an analysis of variance model would be well-suited here to determine the statistically sound application of the catch-per-count ratios.

When the conversion ratio treatment has been resolved, all available hourly entries should be made in the daily catch forms, as shown in Table 13. The catches are grouped for time units 1200-2200, 2200-2300, 2300-2400, 0000-0100, and 0100-1200 hours, with missing hour catches within these periods being calculated by expansion of available catches. Interpolation for an entire missing time unit is not made here, so that these daily sheets will not always give the 24-hour catch. Time unit catches are then entered in tabular form (as in Table 2) so that seasonal ratios of time unit catch per index hour catches may be determined. The 2200-0100 3-hour index catch is used as a common denominator, as every effort was made to have near complete data for this time unit.

The time unit ratios obtained are applied to available time units (as in Table 4) to produce calculated 24-hour totals for each day of fishing. Missed days must be interpolated or given subjective treatment depending upon temperature or visual observation of the smolt outmigration.

Table 12. Weather observation form.

Location Kvichak River Year 1963

Date	Time	Temp.	Max.	Min.	Wind		Cloud Cover				Water		Remarks (Precip., Turbidity, Ice, etc.)
					Dir.	Vel.	0600	1200	1800		Level	Temp.	

Table 13. Kvichak River daily catch form.

Date 6/11-12/63

	Cod End Catches					Photo-Electric Counts						
Hour	Minutes Fished	Hourly Factor	Catch	Calcul. Hourly Catch	Period Catch	Min. Fished	Hourly Factor	Count	Calcul. Hourly Catch	Daily Conv. Factor	Period Catch	Total Period Catch
1200												
1300						15	4.00	167	568	5.04	2863	
1400						60	1.00	1082	1082		5453	
1500						60	1.00	814	814		4103	
1600						57	1.05	228	239		1205	
1700												
1800						240/4	1.00	893	893		4501	
1900												
2000												
2100						60	1.00	170	170		857	
Totals											18982	21091
				18982 x 10/9 = 21091								
2200						58	1.03	195	201	5.04	1013	
2300						60	1.00	234	234		1179	
2400						59	1.02	1	1		5	
Totals											2197	2197
0100												
0200												
0300												
0400						540/9	1.00	38	38	5.04	192	
0500												
0600												
0700												
0800												
0900												
1000	60	1.00	37	37								
1100	58	1.03	4	4								
Totals				41							192	233
Total Daily Catch												23521

Length Frequency Analysis

Length frequency tally sheets were combined to form daily length frequency distributions. These distributions are then weighted according to daily fyke net catch size by use of the following formula:

$$\text{Daily Weighting Factor} = \frac{\text{Daily Catch}}{(\text{Sample Magnitude})\ (\text{Seasonal Catch})}$$

Each daily weighted distribution should be entered on the daily tally sheet. The sum of these weightings for each millimeter length are added for the entire season to produce a seasonal weighted length frequency distribution.

Scale Analysis

As the smolt scales are aged, record should be kept of the date of capture so that each day's weighting factor may be used for the tally for each millimeter group. These are recorded for the portion of the length distribution in which the ages overlap. The length for point of separation is calculated by summing the numbers of Age I and Age II smolt in each millimeter grouping and interpolating to arrive at the point that best separates the majority of each age group within the overlap.

Condition Analysis

Weight and K values from each 3-millimeter group for each condition sample are transcribed from the condition sample sheets into a form as in Table 6. The seasonal catch is then divided into time segments represented by each condition sample and each sample given a weighting value equal to the portion of the total run represented by that time segment. Application of these weighting values will produce a mean seasonal gram weight and K value for each 3-millimeter grouping. To obtain one mean weight and one mean K value representative of each age group, it is also necessary to weight by length frequency distribution. For this, the seasonal weighted length frequency distribution is used. Each 3-millimeter group receives a weighting factor equal to the length frequency values of that 3-millimeter group divided by the total number of smolt in that age group. Thus the sum of the weighting factors for each age group equals 100 percent. When these factors are applied to the respective weight and K values, the sum will produce the mean seasonal weight and mean seasonal K values for each age group.

Literature Cited

Church, W. 1963. Red salmon smolts, Kvichak River system, 1961. Informational Leaflet No. 31, Alaska Department of Fish and Game.

Kerns, O.E. 1961. Abundance and age of Kvichak River red salmon smolts. Fish. Bull. 189., Vol. 61, U.S. Fish and Wildlife Service, Bureau of Commercial Fisheries.

Kerns, O.E., T.S.Y. Koo, and C.O. Junge, Jr. 1961. 1961 summary report on photo-electric counting of red salmon smolts. 1960 Univ. of Wash., Fisheries Research Institute, Circular No. 141.

Kerns, O.E., Jr., and Richard A. Marriott. 1963. Enumeration of red salmon smolt migration. Informational Leaflet No. 25, Alaska Department of Fish and Game.

Martin, J.W. and O.E. Kerns, Jr. 1960. Photo-electric counting of red salmon smolts in the Kvichak River, Alaska. Univ. of Wash., Fisheries Research Institute, Circular No. 114.

Kvichak River Fyke Net Equipment List

1. 1 fyke net skiff
2. 1 large river skiff
3. 1 small skiff
4. 1 35-40 h.p. outboard motor, long shaft
5. 1 18-28 h.p. outboard motor, long shaft
6. 1 10-18 h.p. outboard motor, short shaft
7. 600 feet 3/4 inch manila rope
8. 300 feet 3/8 inch dacron rope
9. Misc. rings, swivels, clips (includes 1 quick-release ring)
10. 5 75-100 lb. navy anchors
11. 4 12-volt truck-size batteries
12. 1 battery charger
13. 2 pair battery jumper-cables
14. 2 battery hydrometers
15. 1 gas pump
16. 2 coleman funnels
17. 2 wall tents (approximately 9' x 12')
18. 2 folding cots
19. 1 table
20. 1 bench
21. 2 coleman gasoline stoves
22. 3 plastic buckets (3 gal.)
23. 2 wash tubs
24. 2 flat enamel pans
25. 1 large set cooking utensils, dishes, etc.
26. 1 set of tools in tool box
27. 2 good fyke nets
28. 3 zippered cod ends (one adapted for tunnel)
29. 1 fyke net tunnel
30. 1 shading tunnel
31. 4 Veeder-Root photo heads
32. 4 Veeder-Root electronic counters
33. 2 Heathkit transformers (double outlet)
34. Smolt weighing basket
35. 1 50-lb. Chattilon spring scale
36. 1 3-lb. spring scale
37. 2 fry baskets (one with suspension wires and weighted to 1 lb.)
38. 1 livebox (double compartment)
39. 1 Ohas triple beam balance
40. 20 plastic condition containers
41. 2 smolt measuring boards
42. 1 500 millileter graduate
43. 1 25 millileter graduate
44. 2 scalpels with blades
45. 3 boxes of glass slides
46. 24 quart glass jars with lids
47. 1 roll masking tape
48. 2 pair surgical gloves
49. 3 spools seine twine (1 heavy nylon, 2 cotton)
50. 3 sack needles

Kvichak River Fyke Net Equipment List (continued)

51. 2 scrub brushes
52. 3 pocket thermometers
53. 3 flashlights with extra batteries
54. 1 headlight with extra battery
55. 1 stopwatch
56. 3 life jackets
57. 50 fyke net log forms
58. 100 smolt length-frequency forms
59. 5 gallons of formalin
60. extra battery acid
61. 150 + gallons of gasoline
62. 25 + quarts outboard motor oil
63. 20 + gallons blazo
64. 100 + gallons of stove oil